510 Rec'd PCT/PTO 21 APR 1999

Practitioner's Docket No. CWR 2 242

CHAPTER II

TRANSMITTAL LETTER TO THE UNITED STATES ELECTED OFFICE (EO/US)

(ENTRY INTO U.S. NATIONAL PHASE UNDER CHAPTER II)

PCT/US98/01195	21 January 1998	21 January 1997
INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED

BUFF-FREE LIQUID CRYSTAL ALIGNMENT USING POLY(IONOMER) COATINGS
TITLE OF INVENTION

PETSCHEK, Rolfe G.; HARRISON, Daniel; and, FISCH, Michael
APPLICANT(S)

Box PCT
Assistant Commissioner for Patents
Washington D.C. 20231

ATTENTION: EO/US

NOTE: To avoid abandonment of the application, the applicant shall furnish to the USPTO, not later than 20 months from the priority date: (1) a copy of the international application, unless it has been previously communicated by the International Bureau or unless it was originally filed in the USPTO; and (2) the basic national fee (see 37 C.F.R. § 1.492(a)). The 30-month time limit may not be extended. 37 C.F.R. § 1.495.

CERTIFICATION UNDER 37 C.F.R. § 1.10*
(Express Mail label number is mandatory.)
(Express Mail certification is optional.)

I hereby certify that this Transmittal Letter and the papers indicated as being transmitted therewith is being deposited with the United States Postal Service on this date April 21, 1999, in an envelope as "Express Mail Post Office to Addressee" Mailing Label Number EL181701145, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

Sally A. Wohlford
(type or print name of person mailing paper)

Sally A. Wohlford
Signature of person mailing paper

WARNING: *Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. § 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.*

***WARNING:** Each paper or fee filed by "Express Mail" **must** have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. § 1.10(b).*
*"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.*

WARNING: *Where the items are those which can be submitted to complete the entry of the international application into the national phase are subsequent to 30 months from the priority date the application is still considered to be in the international state and if mailing procedures are utilized to obtain a date the express mail procedure of 37 C.F.R. § 1.10 must be used (since international application papers are not covered by an ordinary certificate of mailing - See 37 C.F.R. § 1.8.*

NOTE: Documents and fees must be clearly identified as a submission to enter the national state under 35 U.S.C. § 371 otherwise the submission will be considered as being made under 35 U.S.C. § 111. 37 C.F.R. § 1.494(f).

I. Applicant herewith submits to the United States Elected Office (EO/US) the following items under 35 U.S.C. § 371:

a. ☒ This express request to immediately begin national examination procedures (35 U.S.C. § 371(f)).

b. ☒ The U.S. National Fee (35 U.S.C. § 371(c)(1)) and other fees (37 C.F.R. § 1.492) as indicated below:

2. Fees

CLAIMS FEE	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
☐*	TOTAL CLAIMS	20 -20=	0	× $18.00=	$ 0
	INDEPENDENT CLAIMS	3 -3=	0	× $78.00=	
	MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $260.00	
BASIC FEE**	☒ U.S. PTO WAS INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where an International preliminary examination fee as set forth in § 1.482 has been paid on the international application to the U.S. PTO: ☒ and the international preliminary examination report states that the criteria of novelty, inventive step (non-obviousness) and industrial activity, as defined in PCT Article 33(1) to (4) have been satisfied for all the claims presented in the application entering the national stage (37 C.F.R. § 1.492(a)(4)) ..... $96.00 ☐ and the above requirements are not met (37 C.F.R. § 1.492(a)(1)) ..... $670.00 ☐ U.S. PTO WAS NOT INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where no international preliminary examination fee as set forth in § 1.482 has been paid to the U.S. PTO, and payment of an international search fee as set forth in § 1.445(a)(2) to the U.S. PTO: ☐ has been paid (37 C.F.R. § 1.492(a)(2)) ..... $760.00 ☐ has not been paid (37 C.F.R. § 1.492(a)(3)) ..... $970.00 ☐ where a search report on the international application has been prepared by the European Patent Office or the Japanese Patent Office (37 C.F.R. § 1.492(a)(5)) $840.00				
	Total of above Calculations				= 96
SMALL ENTITY	Reduction by 1/2 for filing by small entity, if applicable. Affidavit must be filed also. (note 37 C.F.R. § 1.9, 1.27, 1.28)				- 48
	Subtotal				48
	Total National Fee				$ 48
	Fee for recording the enclosed assignment document $40.00 (37 C.F.R. § 1.21(h)). (See Item 13 below). See attached "ASSIGNMENT COVER SHEET".				40
TOTAL	Total Fees enclosed				$ 88

*See attached Preliminary Amendment Reducing the Number of Claims.

i. ☒ ~~A~~ Two (2) check in the amount of $40 & 48 to cover the above fees is enclosed.

ii. ☐ Please charge Account No. _____ in the amount of $ _____. A duplicate copy of this sheet is enclosed.

***WARNING:** *"To avoid abandonment of the application the applicant shall furnish to the United States Patent and Trademark Office not later than the expiration of 30 months from the priority date: * * * (2) the basic national fee (see § 1.492(a)). The 30-month time limit may not be extended." 37 C.F.R. § 1.495(b).*

WARNING: *If the translation of the international application and/or the oath or declaration have not been submitted by the applicant within thirty (30) months from the priority date, such requirements may be met within a time period set by the Office. 37 C.F.R. § 1.495(b)(2). The payment of the surcharge set forth in § 1.492(e) is required as a condition for accepting the oath or declaration later than thirty (30) months after the priority date. The payment of the processing fee set forth in § 1.492(f) is required for acceptance of an English translation later than thirty (30) months after the priority date. Failure to comply with these requirements will result in abandonment of the application. The provisions of § 1.136 apply to the period which is set. Notice of Jan. 3, 1993, 1147 O.G. 29 to 40.*

3. ☒ A copy of the International application as filed (35 U.S.C. § 371(c)(2)):

NOTE: Section 1.495 (b) was amended to require that the basic national fee and a copy of the international application must be filed with the Office by 30 months from the priority date to avoid abandonment. "The International Bureau normally provides the copy of the international application to the Office in accordance with PCT Article 20. At the same time, the International Bureau notifies applicant of the communication to the Office. In accordance with PCT Rule 47.1, that notice shall be accepted by all designated offices as conclusive evidence that the communication has duly taken place. Thus, if the applicant desires to enter the national stage, the applicant normally need only check to be sure the notice from the International Bureau has been received and then pay the basic national fee by 30 months from the priority date." Notice of Jan. 7, 1993, 1147 O.G. 29 to 40, at 35-36. See item 14c below.

a. ☐ is transmitted herewith.

b. ☒ is not required, as the application was filed with the United States Receiving Office.

c. ☒ has been transmitted

i. ☒ by the International Bureau.
Date of mailing of the application (from form PCT/1B/308): 23 July 1998

ii. ☐ by applicant on _____.
Date

4. ☒ A translation of the International application into the English language (35 U.S.C. § 371(c)(2)):

a. ☐ is transmitted herewith.

b. ☒ is not required as the application was filed in English.

c. ☐ was previously transmitted by applicant on _____.
Date

d. ☐ will follow.

5. ☒ Amendments to the claims of the International application under PCT Article 19 (35 U.S.C. § 371(c)(3)):

NOTE: The Notice of January 7, 1993 points out that 37 C.F.R. § 1.495(a) was amended to clarify the existing and continuing practice that PCT Article 19 amendments must be submitted by 30 months from the priority date and this deadline may not be extended. The Notice further advises that: "The failure to do so will not result in loss of the subject matter of the PCT Article 19 amendments. Applicant may submit that subject matter in a preliminary amendment filed under section 1.121. In many cases, filing an amendment under section 1.121 is preferable since grammatical or idiomatic errors may be corrected." 1147 O.G. 29-40, at 36.

a. ☐ are transmitted herewith.

b. ☐ have been transmitted

i. ☐ by the International Bureau.
Date of mailing of the amendment (from form PCT/1B/308): _____.

ii. ☐ by applicant on (date) _____.
Date

c. ☒ have not been transmitted as

i. ☒ applicant chose not to make amendments under PCT Article 19.
Date of mailing of Search Report (from form PCT/ISA/210.): _____.

ii. ☐ the time limit for the submission of amendments has not yet expired. The amendments or a statement that amendments have not been made will be transmitted before the expiration of the time limit under PCT Rule 46.1.

6. ☒ A translation of the amendments to the claims under PCT Article 19 (38 U.S.C. § 371(c)(3)):

a. ☐ is transmitted herewith.

b. ☐ is not required as the amendments were made in the English language.

c. ☒ has not been transmitted for reasons indicated at point 5(c) above.

7. ☒ A copy of the international examination report (PCT/IPEA/409)

☒ is transmitted herewith.

☐ is not required as the application was filed with the United States Receiving Office.

8. ☐ Annex(es) to the international preliminary examination report

a. ☐ is/are transmitted herewith.

b. ☐ is/are not required as the application was filed with the United States Receiving Office.

9. ☐ A translation of the annexes to the international preliminary examination report

a. ☐ is transmitted herewith.

b. ☐ is not required as the annexes are in the English language.

10. ☒ An oath or declaration of the inventor (35 U.S.C. § 371(c)(4)) complying with 35 U.S.C. § 115

a. ☐ was previously submitted by applicant on _____. Date

b. ☒ is submitted herewith, and such oath or declaration

i. ☒ is attached to the application.

ii. ☐ identifies the application and any amendments under PCT Article 19 that were transmitted as stated in points 3(b) or 3(c) and 5(b); and states that they were reviewed by the inventor as required by 37 C.F.R. § 1.70.

iii. ☐ will follow.

II. Other document(s) or information included:

11. ☒ An International Search Report (PCT/ISA/210) or Declaration under PCT Article 17(2)(a):

a. ☒ is transmitted herewith.

b. ☒ has been transmitted by the International Bureau. Date of mailing (from form PCT/IB/308): 23 July 1998

c. ☐ is not required, as the application was searched by the United States International Searching Authority.

d. ☐ will be transmitted promptly upon request.

e. ☐ has been submitted by applicant on _____. Date

12. ☒ An Information Disclosure Statement under 37 C.F.R. §§ 1.97 and 1.98:

a. ☐ is transmitted herewith.

Also transmitted herewith is/are:

☐ Form PTO-1449 (PTO/SB/08A and 08B).

☐ Copies of citations listed.

b. ☒ will be transmitted within THREE MONTHS of the date of submission of requirements under 35 U.S.C. § 371(c).

c. ☐ was previously submitted by applicant on _____. Date

13. ☒ An assignment document is transmitted herewith for recording.

A separate ☒ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☐ FORM PTO 1595 is also attached.

_____

_____

_____

14. ☒ Additional documents:
    a. ☒ Copy of request (PCT/RO/101)
    b. ☒ International Publication No. WO98/31772
        i. ☒ Specification, claims and drawing
        ii. ☐ Front page only
    c. ☒ Preliminary amendment (37 C.F.R. § 1.121)
    d. ☐ Other

15. ☒ The above checked items are being transmitted
    a. ☒ before 30 months from any claimed priority date.
    b. ☐ after 30 months.

16. ☐ Certain requirements under 35 U.S.C. § 371 were previously submitted by the applicant on _____, namely:

AUTHORIZATION TO CHARGE ADDITIONAL FEES

WARNING: *Accurately count claims, especially multiple dependant claims, to avoid unexpected high charges if extra claims are authorized.*

NOTE: "A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).

NOTE: "Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).

☒ The Commissioner is hereby authorized to charge the following additional fees that may be required by this paper and during the entire pendency of this application to Account No. 06-0308

☒ 37 C.F.R. § 1.492(a)(1), (2), (3), and (4) (filing fees)

WARNING: *Because failure to pay the national fee within 30 months without extension (37 C.F.R. § 1.495(b)(2)) results in abandonment of the application, it would be best to always check the above box.*

☐ 37 C.F.R. § 1.492(b), (c) and (d) (presentation of extra claims)

NOTE: Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1.492(d)), it might be best not to authorize the PTO to charge additional claim fees, except possible when dealing with amendments after final action.

☐ 37 C.F.R. § 1.17 (application processing fees)

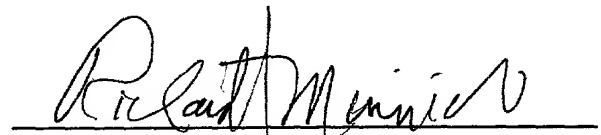
☐ 37 C.F.R. § 1.17(a)(1)–(5) (extension fees pursuant to § 1.136(a).

☐ 37 C.F.R. § 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. § 1.311(b))

NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. § 1.311(b).

NOTE: 37 C.F.R. § 1.28(b) requires "Notification of any change in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying . . . issue fee." From the wording of 37 C.F.R. § 1.28(b): (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

☐ 37 C.F.R. § 1.492(e) and (f) (surcharge fees for filing the declaration and/or filing an English translation of an International Application later than 30 months after the priority date).



SIGNATURE OF PRACTITIONER

Reg. No.: 24,175

Richard J. Minnich

(type or print name of practitioner)

Tel. No.: (216) 861-5582

FAY, SHARPE, BEALL, FAGAN, MINNICH & McKEE

Customer No.:

P.O. Address

1100 Superior Avenue

Seventh Floor
Cleveland, Ohio 44114-2518

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Rolfe G. Petschek et al.
Serial No.	:	Unknown
Filed	:	Herewith
Title	:	BUFF-FREE LIQUID CRYSTAL ALIGNMENT USING POLY(IONOMER) COATINGS
Attorney Docket	:	CWR 2 242

Assistant Commissioner For Patents
Washington, D.C. 20231

37 C.F.R. 1.27 VERIFIED STATEMENT CLAIMING
SMALL ENTITY STATUS-NONPROFIT ORGANIZATION

Dear Sir:

I, Richard A. Zdanis, hereby declare that I am an official empowered to act on behalf of the nonprofit organization identified below:

Case Western Reserve University
10900 Euclid Avenue
Cleveland, Ohio 44106 U.S.A.

TYPE OF ORGANIZATION

(X) UNIVERSITY OR OTHER INSTITUTION OF HIGHER EDUCATION

() TAX EXEMPT UNDER INTERNAL REVENUE SERVICE CODE (26 USC 501(a) and 501(c)(3))

() NONPROFIT SCIENTIFIC OR EDUCATIONAL UNDER STATUTE OF STATE OF THE UNITED STATES OF AMERICA

(Name of State: _____)
(Citation of Statute: _____)

() WOULD QUALIFY AS TAX EXEMPT UNDER INTERNAL REVENUE SERVICE CODE (26 USC 501(a) and 501(c)(3)) IF LOCATED IN THE UNITED STATES OF AMERICA

() WOULD QUALIFY AS NONPROFIT SCIENTIFIC OR EDUCATIONAL UNDER STATUTE OF STATE OF THE UNITED STATES OF AMERICA IF LOCATED IN THE UNITED STATES OF AMERICA

(Name of State: _____)
(Citation of Statute: _____)

I hereby declare that the nonprofit organization identified above qualifies as a nonprofit organization as defined in 37 CFR 1.9(e) for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code with regard to the invention entitled: BUFF-FREE LIQUID CRYSTAL ALIGNMENT USING POLY(IONOMER) COATINGS, by Rolfe G. Petschek et al. described in:

(X) the specification filed herewith
() Application Serial No. _____
filed on _____
( ) Patent No. _____
issued on _____

I hereby declare that rights under contract or law have been conveyed to and remain with the nonprofit organization with regard to the above identified invention.

If the rights held by the nonprofit organization are not exclusive, each individual, concern or organization having rights to the invention is listed below * and no rights to the invention are held by any person, other than the inventor, who could not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

* Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

NAME _____
ADDRESS _____
_____

() Individual () Small Business Concern () Non-Profit Organization

NAME _____
ADDRESS _____
_____

() Individual () Small Business Concern () Non-Profit Organization

NAME _____
ADDRESS _____
_____

() Individual () Small Business Concern () Non-Profit Organization

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at any time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Name of Person Signing: Richard A. Zdanis

Title in Organization: Provost and University Vice President

Address of Person Signing: 10900 Euclid Avenue
Cleveland, Ohio 44106

12/30/98
Date

Richard A. Zdanis
Signature

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Rolfe G. Petschek et al.
Serial No.	:	Unknown
Filed	:	Herewith
Title	:	BUFF-FREE LIQUID CRYSTAL ALIGNMENT USING POLY(IONOMER) COATINGS
Attorney Docket	:	CWR 2 242

Assistant Commissioner For Patents
Washington, D.C. 20231
BOX PCT
Attention: EO/US

PRELIMINARY AMENDMENT

Dear Sir:

Prior to examination of the subject application, please amend the application as follows:

IN THE ABSTRACT:

Please add new page 15 (attached hereto) which contains the Abstract of the Invention for the subject case.

REMARKS

It is respectfully submitted that the subject case in better condition for examination.

Respectfully submitted,

Richard J. Minnich, Esq.
Reg. No. 24,175

FAY, SHARPE, BEALL, FAGAN,
MINNICH & McKEE
1100 Superior Avenue; Seventh Floor
Cleveland, Ohio 44114-2518
(216) 861-5582

CERTIFICATE OF MAILING

I hereby certify that this Preliminary Amendment is being deposited with the United States Postal Service as Express Mail No. EL181701145 in an envelope addressed to: Assistant Commissioner For Patents, Washington, D.C. 20231, on April 21, 1999.

Sally A. Wohlford

Sally A. Wohlford

Abstract of the Invention

The present invention consists of materials and a processing method for coating rigid-rod poly(ionomers) or salts thereof, in a solvent system, directionally on charged surfaces resulting in the formation of liquid crystal display surfaces with planar alignment and pretilt.

BUFF-FREE LIQUID CRYSTAL ALIGNMENT USING POLY(IONOMER) COATINGS

This application claims priority to the filing dates of U.S. Provisional Application No. 60/034,966, filed January 21, 1997 and U.S. Provisional Application No. 60/050,765, filed June 25, 1997.

Field of the Invention

The present invention is directed to liquid crystal materials and a process for preparing a liquid crystal display. More specifically, the invention is directed to coating rigid-rod poly(ionomers), or salts thereof, directionally on charged surfaces resulting in the formation of surfaces with planar alignment and pretilt.

Background of the Invention

Nematic, Smectic C and other liquid crystal devices are routinely used in display applications. They are also used in a variety of other devices, such as variable retarders and laser stabilizers, to control light. Most such devices require alignment layers, that is, layers on the surface of transparent electrodes which cause the special axes of the liquid crystal to align in a specific direction relative to the electrode surface.

The literature concerning liquid crystal displays is vast. The popular book "Liquid Crystals: Nature's Delicate Phase of Matter" by Peter Collings (Princeton Science Library, ©1990) is a readable introduction to the subject and is incorporated herein by reference.

Rubbed polyimides and polyimide-amides are the "standard" material used in the liquid crystal industry today for manufacturing liquid crystal displays. Rubbed nylon 6-6 and rubbed Teflon® are also known and used in liquid crystal research. However, there are few

commercial uses in the liquid crystal industry for these types of alignment layers.

Rubbing, more commonly referred to as buffing, is a technique used to align liquid crystal material deposited onto the surface of a liquid crystal display. In practicing this buffing technique, thin coatings of a long chain polymer are applied to the facing surfaces of the two transparent plates between which the liquid crystal layer is disposed. By subsequently rubbing these coatings with a soft material such as cotton cloth or paper, the molecules on the respective coatings can be oriented so that the long axes of the liquid crystal molecules adjacent the respective plates will align parallel to the rubbing direction. This technique, however, has several inherent disadvantages. First, the rubbing operation introduces unwanted contamination onto the polymer coatings because the materials which are used to rub the polymer are generally something other than the polymer itself. For example, cotton or paper are commonly used to rub or buff the polymeric liquid crystals into the desired alignment. Unwanted contaminants from the paper or cotton buffing medium may remain on the liquid crystal surface after the buffing is complete or may contaminate clean-room manufacturing facilities. Second, the rubbing operation introduces considerable shearing forces on the polymer film and may tear the film away from the substrate during manufacture.

Further, buffing generates static electricity which may modify or destroy the underlying active matrix (transistor array) in certain displays. It is also rather ill controlled and depends on a number of poorly understood parameters such as the exact nature of the rubbing cloth, the processing of the polyimide, the humidity of the manufacturing plant, etc. A significant difficulty is that it is not well understood which

parameters the buffing does depend on. This results appreciable loss of nearly finished (but inoperative) product and loss of through-put.

Materials modified by exposure to Ultra Violet (UV) light are under development. There are some technical difficulties associated with the UV exposure. Achieving and controlling pre-tilt has not yet been well demonstrated in such systems. The chemical reactivity of the starting materials as well as the reactivity of the final structures is a difficulty. However, patterning the direction of the alignment is more easily accomplished by utilizing the UV method.

Langmuir-Blodgett (L-B) films are also under development. However, there is no clear evidence that this can be done sufficiently quickly and reproducibly for a commercially viable manufacturing process. There are also severe cleanliness issues which are of concern in connection with the production of L-B films.

Obliquely evaporated silicon dioxide films are old, expensive technologies. They require rather good vacuums, slow and expensive evaporators, and are not currently used extensively in industry.

Other processes for producing aligned liquid crystal displays are disclosed in the following U.S. patents:

Harsch (U.S. Patent No. 3,941,901) disclose a surface alignment method for liquid crystal cells. The method of Harsch comprises applying to the surfaces of transparent plates bounding a liquid crystal film, a long chain polymer such as polyvinyl alcohol or polyvinyl butyral, which is subjected to a shear thinning technique to cause elongation and alignment of these long chain polymers. The polymers used by Harsch are non-rigid, non-ionic polymers.

Omeis et al. (U.S. Patent No. 5,247,377) relates to a process for producing thin, anisotropic layers composed of liquid crystalline substances. The liquid

crystalline substances are applied in a thin layer to one side of a support having a surface restructured in such a way that the structure is given a preferred direction which determines orientation of the liquid crystalline substance and data storage devices produced.

Various compositions are used to prepare liquid crystal displays. For example, Ahne et al. (U.S. Patent No. 4,619,500) relates to a method for producing orientation layers for liquid crystal displays wherein a solution of an organic prepolymer of polyoxozoles, polythiazoles, polyimidazoles, polyoxazinones, polyoxazine diones or polyquinoxalines is applied to a transparent substrate and subsequently annealed and subjected to an orientation treatment. Such orientation treatments include buffing.

Coates et al. (U.S. Patent No. 5,426,009) relates to a polymeric composite material which is based on a liquid crystal polymer component. The polymeric composite of Coates exhibits a high glass transition temperature of at least 60°C and a scattering texture when deposited as a thin film. The polymeric composites of Coates can be rendered transparent by being heated above the glass transition temperature and/or clearing temperature. The polymeric composites of Coates are obtained by mixing a liquid crystal polymer component, a reactive liquid crystalline component, optionally a polymerization initiator component, and/or further additive components, with subsequent polymerization.

However, up to the present time, it has not been known to utilize a rigid-rod poly(ionomer) composition in a buff-free alignment process to produce a liquid crystal display device having planar alignment and pretilt.

Summary of the Invention

The present invention concerns a composition and method for coating rigid-rod poly(ionomers)

directionally on charged surfaces resulting in the formation of liquid crystal display surfaces with planar alignment and pretilt.

More specifically, this invention relates to a process and class of materials for applying such liquid crystal alignment layers. It consists of applying a dilute, solution of a rigid-rod poly(ionomer) and a low molecular weight ion with the opposite charge, to the surface of an electrode using a directional coating technique such as meniscus coating, capillary action, brushing, or drawing the solution over the surface directionally using a rubber wiper or "squeegee" (doctor bar).

Alternatively, a basic or acidic ionizable rigid-rod polymer dissolved in a solvent of appropriate acidity so that the resultant rigid-rod polymer is charged, may also be used.

Accordingly, an object of the present invention is to provide a buff-free method of producing liquid crystal display devices having acceptable planar alignment and pretilt.

Advantages of utilizing the present rigid-rod poly(ionomer) composition and coating technique compared to the buffing technique of the prior art include, but are not limited to, those set forth below.

A first advantage is that the present process is less invasive in that the polymeric material is added to the electrode surface compared to removal through buffing.

A further advantage of the present process is that the process is cleaner, in that many devices utilizing the technology of the present invention must be manufactured primarily in clean rooms.

Another advantage is that the present process can be performed within the storage and operating temperature of most liquid crystal devices. Prior art polyimides, for example, require a "bake" at an order of

150°C which is outside normal LCD operating and storage temperatures.

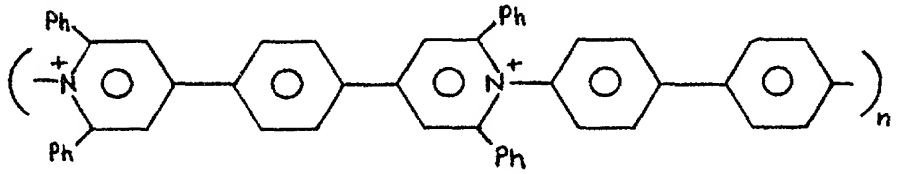
Other advantages and benefits of the invention will become apparent to those skilled in the art upon reading and understanding the following detailed description of the preferred embodiments.

Brief Description of the Drawing

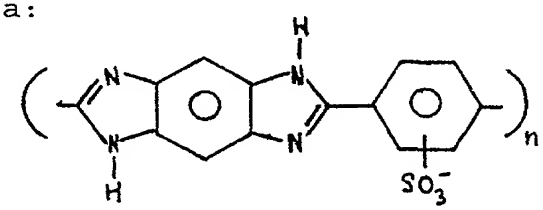
The Figure is a depiction of the process of the invention utilizing a "squeegee" apparatus to apply the rigid-rod poly(ionomer) alignment solution to a glass surface.

Detailed Description of the Preferred Embodiments

Many rigid rod polyionomers are known. A variety of proteins, the polysaccharide xanthan gum and other biological products are essentially rigid rods and have ionic or ionizable moieties attached. There are also synthetic materials such as positively charged poly(pyridinium) salts having the following formula:



wherein the intrinsic viscosity is in excess of 5, and negatively charged poly(benzimidazole - sulfonates) of the formula:



wherein the intrinsic viscosity is in excess of 3.

Each of these synthetic polymers is made by polycondensation reactions. Therefore, structural modifications and the formation of co-polymers should be

well within the ordinary skills of those practicing in the art. Structural modification of rigid-rod poly(ionomers) will permit small changes in pretilt to be achieved in various conditions. It is expected that polyionomers with larger optical polarizabilities along the long axis of the polymer will be superior to polymers without this character for "typical" systems in which the nematic has positive birefringence as this will favor the proposed alignment.

Most liquid crystal display surfaces contain or can be engineered to contain positively or negatively charged ions. The surfaces of glass and indium tin oxide (ITO) generally have "dangling bonds" consisting of negatively charged oxygens which will typically have a hydrogen ion associated with them. However, this hydrogen ion can be easily removed by washing in a weak base. Other surfaces, for example metals and other metal oxides, often have such exposed ions as well. Organic surfaces (e.g. polystyrene surfaces) often do not have such exposed ions (or only a few). However organic surfaces can generally be modified so as to have a number of such exposed ions. For example, a copolymer of styrene and styrene sulfonate will have exposed sulfonate ions on the surface; the addition of a dicarboxylic acid to a polyamic acid prior to heating to drive off water and form a polyimide will result in exposed carboxylic acid ions. Thus many surfaces can be made to have charges chemically bonded thereto. These charged surfaces can then bind oppositely charged polymers such as the rigid-rod poly(ionomers) of the present invention. This will generally result in a surface with the opposite charge of the original base surface which can then again be coated with another polyionomer having an opposite charge. Thus, it is possible to make multi-layered rigid-rod poly(ionomer) coatings on many surfaces.

It is important in a variety of liquid crystal devices to have surfaces coated directionally so that when materials in various liquid crystalline phases are next to the surface they will have specific directions relative to the surface. One important such alignment is a homogeneous planar alignment in which the direction of a nematic liquid crystal phase (which has as its only order a uniaxial alignment of the molecules) aligns close to the surface in a single direction which is close to being in the plane of the surface. The angle which this direction makes to the plane of the surface is important to the operation of many devices and is called the "pre-tilt". This alignment is also important in a variety of devices using smectic C liquid crystals (specifically those based on Clark-Lagerwald cells) as such planar alignment of a nematic is important in the formation of the ultimate alignment of the smectic C liquid crystal. There are additional constraints on the alignment layers in the smectic C phase in such devices, specifically that a "pre-tilted book-shelf" alignment form in the smectic C phase and that there not be a large energy difference between the two different states with polarization toward and away from the surface.

In order to achieve planar alignment with a definite pre-tilt, it is necessary to have a single direction application of the poly(ionomer) composition involved in the coating process. The coating process of the present invention can be practiced with a variety of single direction applicators and techniques, including brushes, meniscus coating techniques, capillary action coating, spraying, and coating with a semi-flexible rubber sheet or "squeegee".

In practicing the coating process according to the present invention, the rigid-rod poly(ionomers) are generally dissolved in an appropriate aprotic polar solvent such as dimethylsulfoxide (DMSO) or water. The

solute is present in a range of from about .005 wt. percent to about .02 wt. percent.

As a final step in the process of the present invention, drying of the coated poly(ionomer) film is essential to remove any excess solvent. Improved results are achieved as the drying time is reduced.

The following example demonstrates coating of rigid-rod poly(ionomers) onto transparent electrode surfaces to form liquid crystal cells using the process of the present invention.

Example 1

In this example, a squeegee was cut to have two sharp angles (approximately 90 degrees) on the side which was designed to engage the surface being coated. The specific coating apparatus is shown in the Figure. The surface being coated was negatively charged ITO coated glass which was cleaned prior to polymer coating. The ITO coated glass was placed horizontally on a hot plate and the hot plate was maintained at a temperature of approximately 60°C. The glass surface was then coated with a solution of poly(pyridinium) salt dissolved in dimethylsulfoxide (DMSO). The squeegee was then brought into contact with the poly(pyridinium) coated surface and drawn across it at a velocity of approximately one mm/second. The downward force on the squeegee was adjusted so that there was a film several microns thick (as observed by optic interference fringes) directly behind the squeegee during the process. The solvent was then allowed to evaporate. The quality of alignment was ascertained by constructing standard liquid crystal cells of approximately 12 microns in thickness with the coating directions of the two substrates aligned anti-parallel, examining the optical properties of both the cell of the present invention and a standard rubbed polyimide cell under a polarized microscope and comparing the alignment of the

cell prepared by the present inventions process to that of the standard cell.

The cell prepared by drawing the squeegee across the rigid-rod poly(ionomer) coated surface one time had reasonable alignment. Further tests have shown that drawing the squeegee across a second or third time with a small amount of the polymer solution in front of the squeegee produced very good alignment.

Use of a chiral polyionomer changes the symmetry of the coated surface. If the coating material is non-chiral then the properties of the surface are unchanged when it is reflected through a plane including the plane normal to the surface and the coating direction. If the system is chiral, no such symmetry exists. In the presence of a mirror plane the alignment direction of the liquid crystal must either be in the mirror plane (observed) or have two degenerate directions which are mirror images through this plane (not yet observed). If there is no such symmetry then the alignment direction is not constrained and can have any relation to the coating direction. A chiral material, xanthan gum, dissolved in water has been applied to ITO coated glass using a brush or squeegee. Good alignment of the liquid crystal is observed at an angle (15 degrees) to the brushing direction. This angle will be proportional to the enantiomeric excess. Such predictable and controllable angular changes of the alignment direction to the coating direction are useful in some applications.

Excellent alignment has been achieved by coating ITO coated glass using a brush and either (i) a poly(pyridinium) salt dissolved in DMSO or (ii) xanthan gum dissolved in water. The coating was performed by brushing the poly(ionomer) coated surface several times at a rate of approximately one mm/second. The surface is brushed first in one direction and then in the opposite direction. The brush should be displaced

perpendicular to the brushing direction between successive brushings. The direction of alignment and pre-tilt are controlled by the direction of the final brushing. As a final drying step, the solvent is allowed to evaporate.

Thermal stability is important in the manufacture of liquid crystal cells. Liquid crystal surfaces prepared according to the present invention have been exposed to temperature of 150-160°C for fifteen to twenty minutes with no apparent degradation of alignment. Visual observation, in fact, suggests some improvement on heat treatment. Similarly, treatment of the surface after coating with solvents may be important in manufacturing. We have verified that washing the surface with the solvents in which the polymers dissolve does not significantly degrade the alignment properties of the surface. Some liquid crystal devices require two different alignment layers (e.g. a homeotropic alignment) (alignment normal to the surface) and a planar alignment with pretilt, as achieved using our surfaces. We have prepared such a cell. It shows the expected alignment. A cell prepared using a squeegee and poly(pyridinium) salt in DMSO was characterized as having pretilt between 0.5 and 1 degrees, which is within the range of industrially interesting pretilts.

The invention has been described with reference to the preferred embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

Having thus described the invention, it is claimed:

1. A coating composition for attaining buff-free alignment of liquid crystals on a liquid crystal display device, the coating composition comprising a positively or negatively charged rigid-rod poly(ionomer) or salt thereof, with (i) a low molecular weight counter-ion or (ii) a basic or acidic ionizable rigid-rod polymer, and a solvent which is capable of dissolving the rigid-rod poly(ionomer) or salt thereof.

2. A coating composition of claim 1 wherein the positively or negatively charged rigid-rod poly(ionomer) is a positively or negatively charged heterocyclic rigid-rod poly(ionomer) or salt thereof.

3. The coating composition of claim 2 wherein the heterocyclic rigid-rod poly(ionomer) is an N-substituted heterocyclic rigid-rod poly(ionomer).

4. The coating composition of claim 2 wherein the heterocyclic rigid-rod poly(ionomer) is a positively charged poly(pyridinium) salt.

5. The coating composition of claim 2 wherein the heterocyclic rigid-rod poly(ionomer) is a negatively charged poly(benzimidazole-sulfonate) or salt thereof.

6. The coating composition of claim 1 wherein the rigid-rod poly(ionomer) is xanthan gum.

7. The coating composition of claim 1 wherein the solvent is a polar aprotic solvent.

8. The coating composition of claim 1 wherein solvent is water or dimethylsulfoxide (DMSO).

9. The coating composition of claim 4 wherein DMSO is utilized as a solvent for the positively charged poly(pyridinium) salt.

10. The process for manufacturing a buff-free liquid crystal display with planar alignment which comprises applying the composition of claim 1 to an oppositely charged surface of an electrode, followed by a drying step wherein the application step causes the axes of the rigid-rod poly(ionomers) to align in a planar direction with pretilt.

11. The process of claim 10 wherein the rigid-rod poly(ionomer) is a salt of a heterocyclic rigid-rod poly(ionomer).

12. The process of claim 11 wherein the heterocyclic rigid-rod poly(ionomer) is a positively charged poly(pyridinium) salt.

13. A process of claim 11 wherein the heterocyclic rigid-rod poly(ionomer) is a negatively charged poly(benzimidazole-sulfonate) salt.

14. The process of claim 10 wherein the rigid-rod poly(ionomer) is xanthan gum.

15. The process of claim 10 wherein the application step is accomplished by a squeegee.

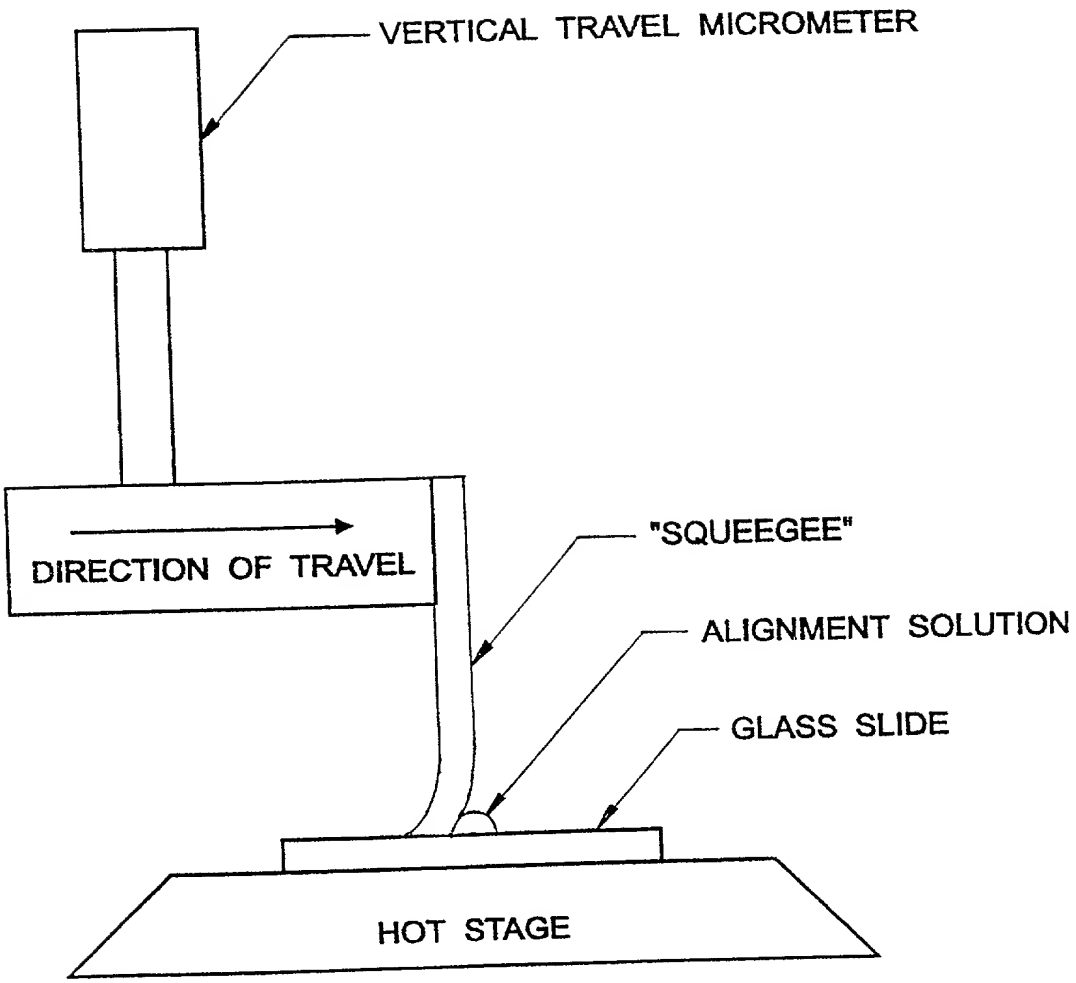
16. The process of claim 10 wherein the application step is accomplished by brushing, spraying, capillary action or meniscus coating.

17. The process of claim 10 wherein the charged transparent electrode surface is glass or indium tin oxide (ITO) having a negative charge.

18. The process of claim 17 wherein a poly(pyridinium), dissolved in DMSO with a counter-ion, is coated by a squeegee onto the negatively charged glass or ITO surface.

19. The process for manufacturing a buff-free liquid crystal display having planar alignment and pretilt which comprises application of a positively charged rigid-rod poly(ionomer) or salt thereof dissolved in a solvent, said application being by a squeegee, to a transparent negatively charged glass or indium tin oxide (ITO) electrode surface followed by a drying step wherein the application via squeegee causes the axes of the rigid-rod poly(ionomer) to align in a planar direction with pretilt.

20. The process of claim 19 wherein the rigid-rod poly(ionomer) is poly(pyridinium) salt and the solvent is dimethylsulfoxide (DMSO).


VERTICAL TRAVEL MICROMETER
DIRECTION OF TRAVEL
"SQUEEGEE"
ALIGNMENT SOLUTION
GLASS SLIDE
HOT STAGE

DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first, and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

BUFF-FREE LIQUID CRYSTAL ALIGNMENT USING POLY(IONOMER) COATINGS

the specification of which:

☒ is attached hereto.
☐ was filed on _____
as U.S. Serial No. _____

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PCT/US98/01195 (Number)	United States (Country)	21 January 1998 (Day/Month/Year Filed)
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

60/034,966	21 January 1997
(Application Number)	(Filing Date)
60/050,765	25 June 1997
(Application Number)	(Filing Date)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Serial No.)	(Filing Date)	(Status)

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